ORIGINAL RESEARCH

Efficacy of Femoral Neck System Fixation vs KHS Femoral Neck Dynamic Compression Locking Plate System in Femoral Neck Fracture

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ABSTRACT

Background • Femoral neck fracture is acknowledged as one of the common injuries in clinical orthopedics. Our study was aimed at investigating the efficacy of femoral neck fixation vs the KHS dynamic compression locking plate system in the treatment of femoral neck fracture.

Methods • This was a prospective study. A total of 90 patients with femoral neck fracture who were admitted to The Third Hospital of Hebei Medical University in Shijiazhuang, China from August 2017 to March 2020 were enrolled in our study. The patients were randomly divided into the control group (45 patients allocated to intervention with the novel femoral neck dynamic compression locking plate system) and the study group (45 patients who underwent femoral neck system fixation). Intraoperative blood loss, surgery duration, fracture healing time and related complications in the 2 groups were monitored and evaluated. The recovery of hip joint function at different times in the 2 groups were closely monitored.

Results • The 2 groups completed the surgery process, and the incision healed. All patients were followed up for 6 to 8 months, with an average follow-up time of 7.01 ± 0.21 months. Surgery duration, length of hospital stay and fracture healing time in the study group were significantly lower than in the control group ($P < .05$), while no significant difference was found in intraoperative blood loss between the 2 groups ($P > .05$). At 1 and 3 months after surgery, hip joint function in the study group was significantly higher than in the control group ($P < .05$), but 6 months after surgery, there was no significant difference between the 2 groups ($P > .05$). There were no complications in the study group, whereas 1 patient had a complication in the control group. The total incidence of complications in the study group was lower than in the control group, but the difference was not significant ($P > .05$).

Conclusion • Femoral neck system fixation demonstrated superior efficacy to the KHS femoral neck dynamic compression locking plate system in femoral neck fracture, and is considered as a valid method for wide application. (*Altern Ther Health Med.* 2023;29(5):97-101).

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BACKGROUND

Femoral neck fracture is acknowledged to be a common injury in clinical orthopedics, accounting for approximately 50% of hip fractures and 48% to 54% of proximal femoral fractures.[1] Patients often have femoral neck fracture because of osteoporosis, impact trauma, falls and other external forces. Due to the anatomy and blood supply of the femoral neck and femoral head, patients should seek surgical intervention after femoral neck fracture, and the need to stay in bed after surgery has a negative impact on patients' quality of life (QoL). Moreover, the incidence of long-term complications and disability are high; avascular necrosis of the femoral head accounts for 10% to 30% of long-term postoperative complications and fracture nonunion accounts for 10% to 33%.[2] Some patients with basic diseases were not in good physical shape and failed to reach the operation index and were excluded from the present study, and other patients received surgical treatment for early activities and functional exercise.

It is always important to choose an appropriate internal fixator for femoral neck fracture, and the best choice is still controversial.[3,4] According to recent studies, there are several internal fixators available in femoral neck fractures.[5] A superior internal fixator should improve the biomechanical stability of fracture fixation and is conducive to fracture healing. However, different internal fixators involve different levels of surgical trauma and biological interference with the femoral head, with varied study results. Therefore, the aim of our study was to

Table 1. Comparison of General Data in the Two Groups

Group	Age (years)	Male/ Female (n)	BMI (kg/m²)	Time from injury to surgery (days)	Cause of injury (n)		Garden Classification (n)		Combined medical disease (n)	Complicated injury (n)
					Traffic	Fall	III	IV		
Study (n = 45)	46.83 ± 5.21	16/29	23.83 ± 1.29	2.98 ± 0.21	9	36	30	15	29	6
Control (n = 45)	46.91 ± 5.32	15/30	23.89 ± 1.34	3.02 ± 0.24	10	35	29	16	28	7
χ^2/t	-0.072	0.049	-0.216	-0.841	0.067		0.131		0.048	0.09
P value	.943	.824	.829	.403	.796		.717		.827	.764

investigate the KHS femoral neck dynamic compression locking plate system vs femoral neck system fixation in the treatment of femoral neck fracture, with an attempt to achieve increased biomechanical stability for minimally invasive surgery.

METHODS

Study Participants

A total of 90 patients with femoral neck fracture were involved in this prospective study. Patients enrolled were consecutive visitors to the orthopedics department of our hospital from August 2017 to March 2020, and they were divided into the study group (n = 45) or the control group (n = 45) according to a random number table. There were 16 male patients and 29 female patients in the study group, age 35 to 64 years, average age 46.83 ± 5.21 years. The time from injury to surgery was 1 to 4 days; average time 2.98 ± 0.21 days. The cause of injury was a traffic accident in 9 patients and a fall in 36 patients. There were 15 male patients and 30 female patients in the control group, age 36 to 64 years, average age 46.91 ± 5.32 years. Time from injury to surgery was 1 to 5 days, average time 3.02 ± 0.24 days. The cause of injury was traffic accident in 10 patients and fall injury in 35 patients. There was no significant difference in the general data in the 2 groups ($P > .05$; Table 1). All the surgeries were performed by certificated and professional orthopedic surgeons. Data collection and analyses were conducted by research fellows. All patients and their families voluntarily participated in our study and signed informed consent forms. This was a non-blind experiment. The study protocol met the relevant requirements of the Helsinki Declaration of the World Medical Association.

Selection Criteria

Inclusion criteria. All patients were age <65 years; the reduction of fractured end was satisfactory (displacement of fractured end <5 mm, deformity of any angle <10°, no "negative support"); complete clinical data were available; patients had good compliance and mental health.

Exclusion criteria. Patients who needed glucocorticoid treatment; long term alcoholics and non-abstainers; had pathological fracture; had lower limb deformity or severe hip disease; had old femoral neck fractures.

Methods

Surgery

Before surgical intervention, the patients with internal diseases were invited to be seen in relevant departments for consultation and given targeted treatment.

The control group was allocated to intervention with KHS femoral neck dynamic compression locking plate system. Epidural anesthesia combined with subarachnoid block was used in all patients. Patients were placed in the supine position, and the surgical area was routinely disinfected and covered. A traction bed was used to reset the patient's femoral neck, with abduction and external rotation, followed by adduction and internal rotation. The degree of internal and external rotation and the adduction angle of the machine were adjusted according to the reduction situation. The reduction was via C-arm X-ray machine until the reduction was satisfactory. If the 2-3 closed reduction failed to meet the satisfactory reduction requirements, it should be further removed after open reduction. The lateral incision of the greater trochanter was taken as the internal fixation incision, and the incision was made layer by layer until the lateral cortex of the femur was exposed. The lateral locking plate (produced by Jiangsu Kangli Medical Instrument Co., Ltd.) was placed on the lateral wall of the femur according to the installation guide. After the position of the plate was adjusted, the guide needle was placed along the guide, and the position of the guide needle was ascertained by C-arm X-ray machine. Three 7.3 mm cannulated lag screws (produced by Jiangsu Kangli Medical Instrument Co., Ltd.) were inserted along the direction of the guide needle. Once the 3 screws were in position, they were pressed evenly at the same time. When the C-arm X-ray showed that the compression fixation between the fracture ends was satisfactory, the tail cap (produced by Jiangsu Kangli Medical Instrument Co., Ltd.) was inserted in the direction of the guide needle. The incision was closed and the drainage tube was placed irregularly.

The study group was allocated to intervention with femoral neck system fixation. The anesthesia and reduction methods were the same as in the control group. The upper edge of the femoral neck was identified, and lateral radiographs should avoid the center of the neck of the femur. The rotation direction of the femoral neck was controlled by 2.0-2.5 mm Kirschner wire. The middle point of the small tubercle was taken from the center, and a 4-cm longitudinal incision was made on the lateral femur to the lateral femur cortex. The femoral neck power rod guide needle was implanted under the guidance of the guide device; the femoral neck diameter was 130° to 135°. The center of the femoral neck was set in the anteroposterior and lateral position. The best distance between the tip of the catheter and subchondral bone was 5 mm. The lateral cortex of the femur was opened by medullary cavity drill, and the femoral neck medullary cavity channel was opened along the guide needle. The power rod was inserted, and the femoral neck system was installed. With the help of the connecting rod, it was gently knocked along the femoral neck channel until it entered the femoral neck medullary cavity. After the lateral femoral cortex and the lateral femoral plate were fitted satisfactorily, 1 or 2 screws were inserted. If the patient was osteoporotic, 2 screws were placed. The pulp cavity of the anti-rotation screw was opened along the guide, and the appropriate length anti-rotation screw was placed. After the fracture and internal fixation were satisfactory according to images from a C-arm X-ray machine, the Kirschner wire was taken out and the incision was sutured layer by layer.

Perioperative and Postoperative Management

Antibiotics were given during the 24 hours after surgery. A sitting or semi-lying position could be taken 24 hours after surgery; straight leg raising of the affected limb was forbidden. Two days after surgery, isometric contraction exercise was performed to exercise quadriceps strength. On the third day after surgery, the patients could walk with walking aids. Rivaroxaban was given orally 10 hours after surgery to prevent thrombosis. One month after the operation, the weight-bearing of the lower limb was 10kg-15kg, and the time of complete weight-bearing was determined according to the fracture healing.

Follow-up and efficacy evaluation

The intraoperative blood loss, surgery duration, fracture healing time and related complications in the 2 groups were observed, and the recovery of hip joint function at different times in the 2 groups was recorded.

Fracture healing evaluation. There was no obvious percussion pain on the surgery side of the hip joint or the affected side of the axial lower limb. X-ray showed that the fracture line was fuzzy, and there was continuous cancellous bone trabecula passing through the fracture line.

Hip joint function. The Harris Hip Scale was used to evaluate the hip joint function of all patients at 3 and 6 months after surgery.[6] The scale covers 4 domains: function (47 points), range of motion (5 points), pain (44 points) and absence of deformity (4 points) for a full score of 100 points. The higher the score, the better the hip function.

Related complications. The incidence of infection, loosening of internal fixation, femoral neck shortening and necrosis of the femoral head were monitored.

Statistical Analysis

IBM® SPSS 21.0 software was used to analyze the data. The measurement data were expressed as $\bar{x} \pm s$, and *t* test was applied. The counting data were described as percentage (%) and chi square χ^2 was used. $P < .05$ represented significant statistical difference.

Table 2. Comparison of Intraoperative Blood Loss, Surgery Duration, Hospital Stay and Fracture Healing Time in the Two Groups ($\bar{x} \pm s$)

Group	n	Intraoperative Blood loss (ml)	Operation time (min)	Hospital stay (days)	Fracture healing time (months)
Study	45	76.29 ± 9.11	53.92 ± 4.39	6.08 ± 1.12	4.22 ± 0.93
Control	45	78.78 ± 9.92	57.92 ± 3.87	7.01 ± 1.09	4.93 ± 0.91
t		-1.124	-4.585	-4.086	-3.660
P value		0.218	<.001	<.001	<.001

Table 3. Comparison of Hip Joint Function in the Two Groups ($\bar{x} \pm s$)

Group	n	1 month after surgery	3 months after surgery	6 months after surgery
Study	45	77.92 ± 6.93	93.83 ± 3.29	95.94 ± 3.31
Control	45	73.98 ± 5.39	91.92 ± 3.02	95.89 ± 3.29
t		3.011	2.869	0.072
P value		.003	.005	.943

Table 4. Comparison of Complications in the Two Groups

Group	n	Infection	Coxa vara	Screw loosening	Femoral neck shortening	Femoral head necrosis (d)	Total complication rate
Study	45	0	0	0	1	0	2.22% (1/45)
Control	45	0	0	1	1	1	6.67% (3/45)
χ^2							1.047
P value							.306

RESULTS

Comparison of Intraoperative Blood Loss, Surgery Duration, Hospital Stay and Fracture Healing Time in the Two Groups

All patients were followed up for 6 to 8 months, with an average time of 7.01 ± 21 months. The surgery duration, hospital stay and fracture healing time in the study group were significantly lower than in the control group ($P<.05$). However, no significant difference was observed in intraoperative blood loss in the 2 groups ($P>.05$), as shown in Table 2.

Comparison of Hip Joint Function in the Two Groups

At 1 and 3 months after surgery, the hip function in the study group was significantly better than in the control group ($P < .05$). However, 6 months after surgery, there was no significant difference in hip joint function in the 2 groups ($P>.05$), as laid out in Table 3.

Comparison of Complications in the Two Groups

There were no complications in the study group and 1 patient had complications in the control group. One case of femoral neck shortening was found in the study group. In the control group, there was 1 case of screw loosening, 1 case of femoral neck shortening and 1 case of femoral head necrosis. The total complication rate in the study group was lower than in the control group, but the difference was not significant ($P>.05$), as shown in Table 4.

DISCUSSION

Femoral neck fracture is regarded as one of the more common fractures in clinical orthopedics, caused by distortion trauma and conduction violence of the hip, which could occur at any age. The main causes of femoral neck fracture are: (1) the many nutrient vascular foramens distributed in the superior region of the femoral neck, with weak biomechanical structure;[7] (2) in the young population, femoral neck fracture is often caused by severe violent damage such as falling from a height, a traffic accident and so on; (3) the main causes of femoral neck fracture are long-term overload walking and exercise. In spite of no obvious symptoms in the initial stage and the ability to move, patients may suffer from aggravated pain in the posterior hip, which is the main reason for them to see a doctor. This kind of fracture is also called fatigue fracture, and has a low incidence and high rate of misdiagnosis and missed diagnosis.[8] At present, patients with femoral neck fracture usually seek different surgical interventions according to different demands.

Fracture reduction and internal fixation are commonly recommended in patients <age 65 years with femoral neck fracture. Unless it is necessary, hip joint catheterization will not be selected as treatment in younger patients with femoral neck fracture. This is because the joint replacement prosthesis implant generally cannot be used for more than 20 years, and has several complications such as infection, prosthesis dislocation, etc.[9] According to the biomechanical characteristics of different types of femoral neck fracture, there are intramedullary nail, locking plate, dynamic hip screw, cannulated screw and other implants used in internal fixation of fractures. Cannulated lag screw is the most widely used implant in clinical practice, and can be applied to various femoral neck fractures with minimal surgical trauma.[10] However, many studies[11,12] have confirmed that internal fixation can easily result in complications such as femoral necrosis, which has a serious impact on patient prognosis. Femoral neck shortening after internal fixation has been found to decrease gait velocity and seems to impair gait symmetry and physical function, which may result in permanent physical limitations.[13] Based on the study by Song, et al,[14] the failure rate after internal fixation was as high as 37%. In the clinical treatment of femoral neck fracture, 3 cannulated screws are commonly used, but the screws are easy to withdraw and can become loose. In addition, dynamic hip screws are often applied in shear fractures, but with serious trauma, there is more bone loss in the femoral neck, not to mention the poor anti-rotation force of a single screw. The locking plate has a high risk of screw breakage. The study by SKáLa Rosenbaum[15] confirmed that cannulated lag screws have a high failure rate in the treatment of Pauwels type III femoral neck fracture. Therefore, the selection of an internal fixator to treat femoral neck fracture has become one of the key topics in clinical research, and has important clinical value.

Numerous studies[16,17] are available that show that the type of femoral neck fracture, fracture reduction effect and prognosis are highly associated with the selection of internal fixation, which is the main factor affecting postoperative fracture healing and femoral head necrosis. The precondition in the treatment of femoral neck fracture is satisfactory reduction, and appropriate internal fixation guarantees a good prognosis. The Swiss Hip Joint Research Group has developed a new method for fixation of femoral neck fracture after 10 years called the femoral neck system (FNS). It is minimally invasive, improves stable anti-rotation force in patients and reduces screw cutting and screw withdrawal.[14,18] Indications for the FNS include patients with femoral neck shear fracture, transcervical fracture and femoral neck sub-head fracture. Contraindications include patients with pathological fracture of the femoral neck, subtrochanteric fracture, femoral head fracture and femoral intertrochanteric fracture. At present, limited reports exist concerning the use of 1 to 3 cannulated screws in the treatment of femoral neck fractures with different cannulated screws in China. Fan, et al.[19] confirmed that FNS fixation exerts good biomechanical stability and significant effects in the treatment of unstable femoral neck fracture.

CONCLUSIONS

The results of our study showed that surgery duration, length of hospital stay and fracture healing time in the study group were lower than in the control group ($P < .05$). Intraoperative blood loss in the 2 groups ($P > .05$) suggested that FNS fixation in the treatment of femoral neck fracture can effectively shorten surgery time, hospital stay and fracture healing time, which contribute to early postoperative rehabilitation. This may be due to the smaller skin incision and less stripping of soft tissue when the FNS was implanted. In addition, the internal reduction method for femoral neck fracture does not need to strip the periosteum and soft tissue at the fracture end, which can promote the recovery of blood circulation function at the fracture end and is conducive to fracture healing. Therefore, the FNS shows potential in terms of small trauma, simple surgery and good biomechanical stability.

The human hip joint is an important joint for weight-bearing and trunk movement coordination. It is also the largest, deepest and most stable joint in the human body. Hip joint injury or pathological changes caused by various factors can seriously affect patients' quality of life (QoL). The Harris hip scale is widely used to evaluate hip joint function.[6] Hence, the Harris hip scale was applied to evaluate hip joint function in patients with femoral neck fracture treated with KHS dynamic compression locking plate system, as well as FNS fixation. According to our results, hip joint function in the study group was higher than in the control group 1 month and 3 months after surgery ($P < .05$). Hip joint function in the 2 groups was comparable 6 months after surgery ($P > .05$), indicating that FNS fixation promoted fracture healing in the early stages and effectively restored hip joint function in a short time. However, with the extension of time, both measures were able to effectively restore hip joint function in patients with femoral neck fracture.

At present, nonunion, infection, loosening of internal fixation, femoral neck shortening and avascular necrosis of the femoral head commonly occur after surgery in femoral neck fracture. The main cause of avascular necrosis of the femoral head is that the blood supply to the femoral head is destroyed, and the fracture can cause different degrees of vascular disconnection, vasospasm and embolism, leading to avascular necrosis of the femoral head. According to Zielinski, et al[20] femoral head necrosis is one of the most serious complications, with an incidence as high as 10% to 43%. Zhang, et al.[18] also confirmed that the incidence of femoral head necrosis was 17.4% after treatment of Pauwels type III femoral neck fracture with cannulated lag screws. The results of this study showed that the total incidence of complications in the study group was lower than in the control group; the difference was not statistically significant ($P > .05$). There was 1 patient in the observation group and 1 in the control group with femoral neck shortening, which healed after 3 months. In the control group, there was 1 patient with screw loosening with fracture healing. The patient in the control group received joint replacement for femoral head necrosis.

It was suggested that the FNS fixation and KHS femoral neck dynamic compression locking plate system can effectively reduce the incidence of postoperative complications in patients with femoral neck fracture, and the FNS fixation had fewer complications and a higher safety profile. The reasons proposed were: (1) the fixation of the FNS has a minimally invasive design, the length of the lateral opening is 4 cm to 5 cm, and only 1 incision is used to place the femoral neck power rod, lateral locking plate, locking screw and anti-rotation screw. The gluteus medius tendon will not be injured. (2) FNS exerted biomechanical advantages. Stoffel, et al[21] compared the biomechanical characteristics of dynamic hip screw, dynamic hip blade screw and FNS fixation ($P < .05$). The study suggested that the FNS fixation could provide stable internal fixation in patients with unstable femoral neck fracture, but this study was only in cadavers and the sample size was small. Compared with the 3 cannulated screws, FNS fixation promotes the stability of the overall structure, and the small incision and lesser trauma also decrease the amount of bleeding and preserve the bone. (3) FNS fixation has the advantage of anti-rotation. The power rod of the FNS fixation can be squeezed to the adjacent bone in the process of implantation. Combined with anti-rotation screw and the nail, it can promote the overall biomechanical stability and increase the anti-rotation force. Furthermore, the percussion placement method was used in the FNS fixation, which prevented the secondary rotation displacement of fracture caused by rotation torque. (4) Sliding compression was applied via the FNS. It has 20-mm compression space, which can promote fracture healing. The sliding mechanism in the process of fracture healing and the absorption of the fracture end of the femoral neck can promote the re-contact of the fracture end.

Both the FNS fixation and the KHS femoral neck dynamic compression locking plate system showed potential in the management of femoral neck fractures. However, FNS system fixation elicited superior outcomes in terms of shortening hospitalization time and fracture healing time, with early rehabilitation of hip joint function in patients with femoral neck fractures. This method also has a high safety profile with no complications.

Study Limitations

This study had several limitations: (1) the sample size in this study was small. Further investigation is warranted regarding body weight and age grouping; (2) this is a single center study, and a multicenter randomized controlled study should be part of future research; (3) due to the short follow-up time in this study, some important outcomes, like avascular necrosis, were not evaluated. Therefore, more studies with longer follow-up time should be carried out in the future.

AUTHOR CONTRIBUTIONS

Haili Wang and Bo Wang contributed equally to this paper.

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